one of which was provided with two simple prisms, the other having three compound prisms. The spectra being obtained, the inclination of the spectral lines and the difference of wave-length of the light coming from the two opposite equatorial limbs of the planet is measured, and after corrections being applied for the inclination of the planet's equator to the line of sight, the resulting displacement indicates the equatorial velocity. As the light from the planet is reflected sunlight, the value measured is, of course, double the actual velocity.

The complete measures from fourteen plates taken with the two-prism spectrograph, and from five obtained with the instrument furnished with three compound prisms, are given. The values adopted are the means of measurements of from six to sixteen spectrum lines on each plate.

The photographs were obtained on the evenings of March 25, 30; April 4, 6, 7, 8, 10, 11, 20, 28; May 4, 5, 13, with exposures varying from 7m. to 60m. The angular diameter of the planet varied from 8″·6 to 11″·0. With the 30-inch refractor, of about 40 feet focal length, the linear diameter at the principal focus was 1·2 mm., and this was further reduced by the relative foci of collimator and camera objectives to 0·8 mm. on the photographic plate.

From the difficulty of the determination it is to be expected that the several means should vary for the different plates; but the extreme values given still prove the short rotation period. Taking the diameter of Venus to be 12,700 km., the values of the equatorial velocity (v) are as follows, the corresponding time of rotation (T) being placed under each:—

v =	0·7	0·5	0·462	0·45	0·3 km. per sec.
T =	15·9	22·1	24·0	24·6	37·0 hours.

The author expresses the hope that the astronomers having the control of the large telescopes at the Potsdam, Lick and Yerkes Observatories will repeat his observations for confirmation or revision.

NEW VARIABLE IN AURIGA.—Dr. T. D. Anderson, of Edinburgh, announces in the *Astronomische Nachrichten* (Bd. 152 No. 3642), the detection of a new variable star in Auriga. It is not charted in the B.D., and has the following position:—

$$\left.\begin{array}{l}\text{R.A.} = 6\text{h } 0\cdot9\text{m.}\\ \text{Decl.} = +50^\circ\ 14'\end{array}\right\}(1855\cdot0)$$

The changes in brightness during April and May 1900 were from 8·3 to 8·8 magnitude.

PHOTOGRAPHIC OBSERVATIONS OF SATELLITE OF NEPTUNE.—In the *Astronomische Nachrichten* (Bd. 152 No. 3642), M. S. Kostinsky gives the particulars relating to a series of determinations of the satellite of Neptune, obtained from measures of photographs taken with a telescope of 13 inches aperture at Pulkowa. Many of the difficulties encountered in the photographic delineation of two neighbouring objects of very different brightness have been previously discussed by the author (*Bull. de l'Acad. Impér. des Sc. St. Pétersbourg*, vol. vii. November 1897). In the present case of Neptune the problem is rendered slightly less difficult by the feeble brightness of the planet and the slow movement of the satellite.

The photographs described were obtained during the period 1899 February 4–March 25, the plates having exposures varying from 20m. to 60m. A table giving the corresponding calculated and observed values shows the method to be very accurate.

SOME NOTES ON THE LATE PROF. PIAZZI SMYTH'S WORK IN SPECTROSCOPY.

LAMENTING, as we must do, that time has stolen from us a mighty Ajax in the field of science, a sturdy, patient Atlas who through more than half of this fast waning century robustly upheld on his strong shoulders the growing spires and architraves of science's ever-increasing edifice, it is with keenest sorrow that the writer of these notes turns over the ample pages, rich to profusion in details and superb in colour, of the monumental works of spectroscopy left to us by the late Prof. C. Piazzi Smyth, with the nearly hopeless intention of endeavouring to give a short account of some of his most conspicuously important contributions to that branch of science. The late Prof. Smyth was, indeed, no *dilettante* in the intricate and difficult but fertile and alluring byways of science to which his leisure moments were devoted; and he was far from conceitedly or affectedly pedantic in the grasp of science which he brought to bear upon his philosophical investigations. Although these embraced a range of astronomical and meteorological subjects which would singly engage all the energies of most men, and their whole lifetimes to study with success, yet his mastery of the state of science in the questions which he set himself to solve or to explore, was acquired with so much inventive skill, unsparing pains and ardour, as always to make the character of the work which he accomplished in them permanent and thorough. Well accustomed as he was from his youth, and trained from boyhood,[1] to delicate telescopic, angular and micrometrical measurements by eye and hand, he further possessed a gift of great artistic skill in committing to paper, canvas, and even to frescoes, beautiful drawings, photographs and coloured paintings of the scenes of travel which he witnessed, and of sights which clouds, the heavens, or his laboratory experiments disclosed to him. This accomplishment, well illustrated, long ago, by his publication in the Edinburgh *Philosophical Transactions* (vol. xx. pt. iii.) of a scene of darkness on the coast of Norway, near Bergen, during the Total Solar Eclipse of July 1851, contributed again in colours from his original, carefully kept paintings of the scene, together with a similar view of the Zodiacal Light as seen at Palermo in April 1872, to a new illustrated work on astronomy published by Messrs. Cassell and Co. in 1894, led him to leave to others the study of the actinic spectrum-regions with the aid of photography, and to restrict his spectrum-measurements entirely to all that could be seen and measured by the eye alone, of the solar spectrum, or of the characteristic features of gaseous bright-line spectra, in the whole visible portion of the spectrum only.

In his keen perception of all the grand sublimities of law and order by which Nature's works are everywhere controlled and guided and sustained, and in the constant intentness of his mind to seek out these nature's workings, and to promulgate lucidly and clearly his own perceptions and interpretations of them, Kirchhoff's great discovery, in 1859, that the chemical constitution of the sun could be read in its light's prismatic spectrum, constrained him like a spell, as it quickly did many other physicists, to devote much of his leisure time and abilities to spectro-chemical researches. New striking truths were taught in 1860–61 by Sir William Huggins' not less surprising discovery from observations of their spectra, of the gaseous conditions of certain nebulæ, and by Sir David Brewster's and Dr. J. H. Gladstone's majestically mapped separation from the really solar dark lines in the sun's spectrum, of its low sun, or terrestrial atmospheric lines, soon afterwards distinguished by Secchi, Ångström and the first detector of the "rain-band" near solar D, in America, Dr. J. P. Cooke, and especially by Dr. Janssen's observations among the high Alps of Switzerland and experiments with a long steam-tube in Paris, in 1866–7, into "aqueous-vapour" and "dry-air" telluric lines. Kirchhoff's and Hofmann's first chemical investigation of the solar spectrum was rapidly extended in the years from 1859 to 1868, with tables of metallic and other elementary line-spectra by Huggins and Miller, Mascart, Plücker, Ditscheiner, Van der Willigen, Thalen, Lockyer and others, into a wonderfully novel panorama field of spectrum-analysis, chiefly applicable at first to celestial chemistry and physics, but in such skilled hands as those of Bunsen, Crookes, Reich and Richter, and later of Lecoq de Boisbaudran and other able chemists, to the discovery also of new terrestrial elements. The appearance at Upsala, in 1868, of Ångström and Thalen's classically accurate and chemically expounded "Normal Solar Spectrum" map, with its line-places in a natural diffraction-spectrum order of wave-length progression reckoned in "tenth-metres," or $(10)^{10}$th parts of a metre as scale-units of wave-length,[2] and the detection with spectroscopes in the total solar eclipse of the same year in India, of the hydrogen-flame nature of the sun's red prominences, seen in full sunshine there by Dr. Janssen and almost simultaneously also by Sir J. N. Lockyer in England, afforded to the new

[1] Under Sir Thomas Maclear's care, in 1836, at the age of seventeen; at the famous Observatory at the Cape of Good Hope, where, during the last three years, the presence of oxygen was discovered by its line-spectrum in certain southern stars by the indefatigable English amateur astronomer, Mr. F. Maclean; and where both that discovery and another by Sir J. N. Lockyer of the presence of silicium in the same stars, have been confirmed, and made independently by its energetic Director, Sir David Gill, with a noble spectrophotographic 24-inch refracting telescope presented to the Observatory under his own directions and liberal care for its completeness by the same munificent explorer of stellar spectra in the northern and the southern heavens, Mr. Frank Maclean.

[2] It has now become a common usage in spectroscopy, microscopy and molecular physics, to reckon such small quantities as light wave-lengths in a tenfold larger unit than the Ångström one, denoting it by "$\mu\mu$," the thousandth part of "μ," the thousandth part of a millimetre, "mm."

study of spectroscopy at once a sound philosophic basis for spectrum-definitions, and a new territory of interesting astronomical investigations in the sun's glowing atmosphere, upon which it was not remiss or slow to grow up in strength and stature, expanding itself largely in new observational, practical and theoretical directions, in the next following interval of ten or fifteen years.

From the graphic mementos which he kept, as we have seen, of the total solar eclipse of 1851, and from his successful attempts, described in 1858 in his well-known and most attractively illustrated volume on Teneriffe, to prove by visits (in that year, and again in 1868) to the Island and Peak of Teneriffe, the practical benefit to be obtained in astronomical observations, of avoiding in great part the atmosphere's absorbing action on the light of stars and planets by establishing observatories on mountain heights, it cannot be doubted that these discoveries with spectroscopes concerning the bright, ruddy light-flakes seen round the sun, or round the moon's disc when the sun is totally eclipsed, and regarding the particular rays of the sun's light which undergo absorption in the earth's atmosphere, would, as important contributions to our extremely circumscribed knowledge of the materials and physical conditions of planetary and stellar atmospheres, greatly impress and interest him.

In the preface of his "Spectre Normale du Soleil," Ångström pointed out that the spectrum of the aurora, as he had frequently observed it in the winter months of 1867-8, consisted almost entirely, as Dr. O. Struve at Pulkova, on hearing from Prof. Ångström of this discovery also confirmed it in May 1868, and as Prof. Ångström had previously found to be the case with the spectrum of very bright appearances of the zodiacal light at Upsala in March 1867, of a nearly solitary bright yellow line. Many exact corroborations of this line's conspicuousness, and detections of several less constant bright and faint auroral lines were thereupon made by observers of a series of fine red auroras which at the time of the marked maximum of sunspot frequency in 1870 appeared during the years from 1869 to 1871. A paper recommending Prof. Swan's well-known blue gas-flame, or blowpipe flame spectrum with its five well-determined line or band-edge positions as a most suitable one for reference in mapping auroral spectra, was sent in 1870 by the late Prof. Piazzi Smyth to the Royal Astronomical Society in London; but owing to his describing the flame-spectrum as Prof. Swan had done in 1856, and as did also Ångström in the introduction to his "Solar Spectrum Atlas" in 1868, as the spectrum of hydrocarbons, or of acetylene, it remained unpublished on account of the doubtfully correct chemical apellation given in the paper to this important set of spectrum-bands. Yet the same chemical origin, describing it as probably that of acetylene, was attributed to this spectrum both by Profs. Liveing and Dewar at Cambridge, and by Ångström and Thalen in their "Spectres des Metalloïdes" at Upsala, in 1875; and Prof. Smyth never felt induced to resign the view which he held in such good company, by the contrary opinion steadfastly maintained by many not less skilled and experienced and at least as chemically well versed spectroscopists, that the blue candle-flame's spectrum of delicately fluted bands was not really due to any chemical compound of carbon with other elements, but to carbon itself in one of the modes of molecular aggregation into which, like the materials of some other metalloids at least, the substance of carbon in its volatilised state is liable, by temperature or by some sufficient chemical or electrical powers of dissociation to be broken up.

Another very similar band-spectrum to the Bunsen-flame one, agreeing in the positions of its two brightest (citron and green) band-edges pretty closely with two corresponding bright band-edges of the latter spectrum, but differing from it throughout in its more numerous remaining bands' positions, and with all its bands evenly shaded, instead of (as in the other spectrum) both fluted and shaded off towards the blue direction, only too often seen mingling with the latter spectrum to some extent in nearly all electrically excited vacuum-tubes, can be very readily produced in its natural purity with ordinary induction-sparks in carbon oxide or di-oxide vacuum-tubes; and it was described on that account, in their "Spectres des Metalloïdes" in 1875, by Ångström and Thalen, and after some hesitation about its possible chemical nature in his first paper on "Gaseous Spectra in Vacuum-tubes under Small Dispersion" in 1880,[1] it was afterwards regarded also by the late Prof. Piazzi Smyth as belonging to carbonic oxide. Appearing as these two spectra do almost ubiquitously as impurities in ordinary gas-vacuum-tubes, their precise discrimination from each other, and the resolution of their many hazy bands into as many ranks of scores upon scores of accurately measured linelets, was a work of exact spectrometry in which the great light-intensities of his vacuum-tubes and the powerful train of prisms finally used by Prof. Smyth for the maps of gaseous spectra which he constructed in 1884,[1] accomplished some of the most wonderfully perfect and beautiful achievements. The much debated experimental evidence as to the chemical origins of these two spectra, moreover, prepared the way for some most embracing views of the modes of production of stellar and celestial spectra, which, besides providing astronomers with the means of classifying stars and the lesser lights of nebulæ and comets methodically, also afforded chemists an imposing outline of problems for consideration, of apparently successive stages of subdivision of the elementary forms of matter from dense into light-atomed elements.

In Sir J. N. Lockyer's hands the condensed spark of a Leyden-jar introduced into the vacuum-tube circuit (which Prof. Smyth never used, having decided to confine himself to weak-spark or low temperature excitations only in his spectrum-measures), supplied a method of transition from the oxy-carbon spectrum in carbon-oxide and dioxide vacuum-tubes, directly to the hydrocarbon or blue gas-flame one,[2] showing that only a rise of temperature was needed, from that of the nearly continuous induction-spark or simple brush-discharge in rarefied gas-tubes, to the vastly hotter disruptive spark (instantly volatilising gold-leaf or thin metallic wires), of a Leyden-jar and air-gap in the outer circuit, to furnish a new spectrum, not, we must conclude, by any chemical change of substance, but by disgregation, it seemed evident, of cool and dense into hot light molecules of pure carbon, which could thus be made at pleasure to give either of these two spectra in succession. The flame, and tube spectra, or the hydrocarbon and carbonic oxide ones are therefore now usually referred to, by Sir J. N. Lockyer, as the "hot carbon" and the "cool carbon" spectrum, respectively.[3] But all the best means that can be used to obtain, on the one hand, an evenly ascending scale of temperature and uniform intensities of action of discharges of the electric arc and spark (the only sufficient known means which can be used to reach the high temperatures demanded), and on the other hand the requisite chemical purity of the substances submitted to spectroscopic examination, are so very liable to unsuspected failures from the many lurking sources of deception which most insidiously waylay and falsify the observations and conclusions, that although, on both sides, these sources of error have been unremittingly sought out and often most startlingly disclosed and very skilfully eliminated, it is difficult to say yet whether the distinctive attributes in which the substances which give the different banded carbon spectra really differ fundamentally from each other, are either, as was at first supposed, simply chemical, or else, according to a subsequent suggestion, attributing to pure carbon spectroscopic properties which are at least not at variance with those of oxygen, hydrogen, sulphur, selenium and phosphorus, of an entirely structural kind; that is to say, gaseously allotropic, or molecularly disgregational under the action of increasing temperature. New discoveries and fresh discussions of these bands must doubtless be awaited before we can be definitely sure to what extent the views expressed by different observers as to the chemically compound or elementary dissociated natures of the material sources of special series of shaded or fluted bands seen in banded carbon spectra can be fully trusted.

Besides the two chief ranks already mentioned, there is another

[1] Edinburgh *Philosophical Transactions*, vol. xxx. (1883), pp. 99, 104. In a letter to NATURE (vol. xx. p. 75), in May 1879, on "End-on Vacuum-tubes brought to bear on the Carbon and Carbohydrogen question," the late Prof. Piazzi Smyth also adopted at first without reserve the view of this spectrum that it is produced by carbon simply.

[1] "Micrometrical Measures of Gaseous Spectra under high Dispersion," Edinburgh *Philosophical Transactions*, vol. xxxii. Pt. 3 (1886). The end-on vacuum-tubes used in these measures and in those of the earlier paper, were devised by the late Prof. Smyth himself, as described in a paper, "End-on Vacuum-tubes in Private Spectroscopy," read before the Royal Scottish Society of Arts in 1879. The eminent spectroscopist of Ghent, in Belgium, Dr. van Monckhoven, had, however, invented and used such tubes a few years earlier. An ingenious arrangement of electrodes which he applied to them in 1882 (one electrode at the foot, and one at the summit of each upright leg), for passing two discharges of different strengths, either simultaneously or alternately through the connecting capillary tube, in a research on the effects of temperature and pressure in widening gas-spectrum lines, was described in an interesting paper by Dr. van Monckhoven, in *Comptes rendus*, vol. xcv. (2me semestre, 1882).

[2] "Carbon and Carbon-compounds," by Prof. A. S. Herschel, NATURE, vol. xxii. p. 320, August, 1880.

[3] "Researches on the Spectra of Meteorites," *Proceedings* of the Royal Society, vol. xliii. pp. 118, 133, Map 3, November, 1887.

group of two carbon-bands, usually accompanied by a preceding one close-following the gas-flame spectrum's blue beam, near the Fraunhofer rays *h*, H, at the violet confines of the visible spectrum. All three are seen brightly in the spectrum of the electric arc between carbon poles, where the furthest member of this blue, violet, and ultra-violet array produces a just ocularly visible *pharos*-like mass of grey-looking light slightly beyond the spectrum-place of the furthest visible pair of dark lines H, K, of the solar spectrum. This strong outlying pair and its near preceding blue band were referred by Profs. Liveing and Dewar,[1] and also, when he found the two chief bands bright by themselves in his spectrum photographs of the Comet 1881, III., by Sir William Huggins,[2] to cyanogen. But the same strong pair's violet, or first colonnade, between G and *h*, when he first traced it beautifully distinct and bright with the ordinary coil-spark in an end-on marsh-gas vacuum-tube,[3] was coupled on by Prof. Piazzi Smyth, in his "Measures of Gaseous Spectra with High Dispersion," 1884, as it was also grouped by Dr. W. M. Watts in his "Index of Spectra," 1872 (and where Sir J. N. Lockyer classed all these three flutings provisionally together,[4] from a careful survey made in 1880[5] of their deportments, in an unstable-systemed extension, "B," of the "hot carbon's" ordinary set of flutings, "A"), as a sixth or extra fluted-band transcending in refrangibility all the five commonly seen ones of the "hydrocarbon," or blue gas-flame series.

Six of the seven main lines of the blue band of this set were marked as measured lines distinctly, by Prof. Piazzi Smyth, in a hazy glow of light immediately following the fourth, or blue band of his "High Dispersion Spectrum" Paper's full-length map of the "hydrocarbon" spectrum, but as considerably weaker lines than those of the violet or "marsh-gas" band. As the blue band, however, is in fact the weakest one of a group of bands which only the exceedingly hot flame of cyanogen, or the intense heat of the electric arc, or jar-spark usually produces, its exact indication there, precisely in its natural inferiority of strength to the violet array, and with only one line missing of its seven, at the beginning of the hazy glow, is a speaking testimony to the faithful accuracy of the late Prof. Piazzi Smyth's spectrum records, as well as to the watchful care with which all the spectra which he mapped were guarded against contaminating admixtures of interloping gas-spectra; since with the modest 2–3 inch sparks which he was content to use, of a simple induction coil, nothing but the lamp-like brightness of the Salleron and Casella end-on tubes examined, and the chemical purity of the contents of those used in taking final spectrum measures, could have been expected to show the weakest of the three "cyanogen" bands so equally free from other spectrum-glares, and almost as sharply well-defined in position, as its bright violet companion tier of "marsh-gas" lines was seen and measured.

The fifth (faint violet) band—or the latter part of it—seen under high dispersion to contain only hazy linelets, with no strong lines or sharp-edged flutings, is the only visible light-beam in the Bunsen-flame spectrum which Sir J. N. Lockyer seems willing to admit,[6] can be described correctly as a "hydrocarbon" band; and in his splendid series of discriminations of celestial spectra, that brightest portion of the Bunsen flame's violet band forms the whole system of spectroscopic bands which in those analyses of celestial spectra is usually indicated as characteristically denoting hydrocarbon radiation. Two small bands, or fluted line-groups, however, sometimes occur also in this unstable violet, or "Carbon-B" region, of which one is classed by Sir J. N. Lockyer together with the *pharos*-like band beyond H, K, as an invariable accompaniment (much more refrangible than the four "Carbon-A" bands) of the "hot-carbon" spectrum. This small three-lined band falls exactly in place and width on the Bunsen-flame spectrum's fifth, or violet band's preceding zone of weak hazy light, as the late Prof. Piazzi Smyth, in his full-length map and micrometric measures of that spectrum pictured it, surrounding the place of the violet line Hγ almost as closely as its bright following "hydrocarbon" light-zone surrounds the dark solar line G's position, with a curiously prominent solitary bright line in the dark partition space between them. A fairly satisfactory explanation of this fifth band's construction might thus, with no material need of any reconciling adjustment to the "Carbon-B" band's line-places, be extracted from the Edinburgh spectrum record, by supposing the first and second portions of its divided light-field to belong really to different radiant sources, and to be due, independently of each other, respectively to "hot carbon" and to "hydrocarbon gas's" incandescence. But the near agreement in position between the flame-band's feeble front-domain of shapeless light-haze, and the "hot carbon's" small three-ribbed fluting lacks far too much from being well affirmed by exact co-ordinations to be any certain evidence of a real spectroscopic or physical connection; and the weak preceding portion of the violet flame-band has thus been very appropriately consorted by Sir J. N. Lockyer with the following bright portion of this violet haze-band, as belonging both together to the hydrocarbon spectrum.[1] Another small violet-region band was traced by Sir W. Huggins in the spectrum of the Comet 1881, III., where it lay between the violet and the ultra-violet "cyanogen" bands, a little beyond *h* towards the line H of the solar spectrum.

Among this "Carbon-B" *suite* of bands, suspected by Sir J. N. Lockyer at an early stage of his spectroscopic observations of the sun, in 1874, to have counterparts in the dark lines of the solar spectrum, the strong *pharos*-like ultra-violet fluting's delicate train of bright lines and linelets was at length photographically proved by Sir J. N. Lockyer, in 1878,[2] to coincide precisely with a close-packed orderly array of faint, exceedingly fine dark lines at the same place in the solar spectrum; and the same coincidence of about thirty serrations of this band in ten Ångström's wave-length units, with as many exactly corresponding ripplings of light and darkness at the ultra-violet confines of the sun's visible spectrum was again very abundantly well proved by Profs. Trowbridge and Hutchins at Hartford, U.S., in 1887.[3] It was also pointed out by Profs. Liveing and Dewar at the close of the second of their above-quoted papers, in 1880, on the "Spectra of Compounds of Carbon with Hydrogen and Nitrogen," that a fluted ultra-violet band in the spectrum of the cyanogen-flame, of which they photographed many in an ultra-violet region extending far beyond this grey one's position, exactly coincided in spectrum-place with the remarkably fluted ultra-violet dark band P, in the solar spectrum. After Sir W. Huggins and Padre Secchi had independently detected the "hydrocarbon's" or low gas-flame's bands in the spectrum of Winnecke's Comet, in 1868, and some ten or twelve comets in as many following years were found to show the same bands in their spectra,[4] together with occasional traces of the oxy-carbon or "cool-carbon" spectrum, a far wider range of the "hot" and "cool carbon" bands was presently discovered for them by Sir J. N. Lockyer among the spectra of celestial bodies, and in his "Researches on the Spectra of Meteorites," in 1887,[5] and in the Bakerian Lecture to the Royal Society on a "Suggested Classification of the various Species of Heavenly Bodies,"[6] the low gas-flame's or hot carbon spectrum's bands were clearly shown to exhibit themselves, with rarer excrudescences of cool carbon bands, not only in comets, but alike in sun-like and fluted, and bright-line and temporary stars, and even in nebulæ, the aurora, and sometimes in lightning-flashes, as a sort of torch-light glow of colliding meteorites, condensed meteoritic swarms, and electrically gasified and illumined meteoritic dust, throughout the universe.

It surely needed then only the recent discovery by Prof. G. E. Hale and his coadjutors, Mr. W. S. Adams and Prof. Frost, in

1 "On the Spectra of the Compounds of Carbon with Hydrogen and Nitrogen." Two Papers, Nos. i., ii. *Proceedings* of the Royal Society, vol. xxx. p. 152 and 494, February–June, 1880.

2 *Proceedings* of the Royal Society, vol. xxxiii. p. 1, November 1881.

3 It was also seen by Dr. W. M. Watts ("On the Spectrum of Carbon," NATURE, vol. xxiii. p. 197, December, 1880), "very bright" in a pure Marsh-gas vacuum-tube; and in a methyl vacuum-tube by Dr. Plücker.

4 The Bakerian Lecture, "Suggestions on the Classification of the various Species of Heavenly Bodies,"—"Radiation Flutings": *Proceedings* of the Royal Society, vol. xliv. p. 53, April, 1888; and "Appendix to the Bakerian Lecture," Section vi. "General Statement with regard to Carbon," *Proceedings* of the Royal Society, vol. xlv. p. 186, November, 1888.

5 "Further Note on the Spectrum of Carbon," *Proceedings* of the Royal Society, vol. xxx. p. 461, May, 1880.

6 "Researches on the Spectra of Meteorites," *Proceedings* of the Royal Society, vol. xliii. p. 118; November, 1887.

1 The Bakerian Lecture:—"Radiation Flutings," *Proceedings* of the Royal Society, vol. xliv. p. 53, April 1888.

2 "Note on the existence of Carbon in the Coronal Atmosphere of the Sun," *Proceedings* of the Royal Society, vol. xxvii. p. 308, April, 1878.

3 "On the Spectrum of Carbon compared with that of the Sun," *Proceedings* of the American Academy of Arts and Sciences, vol. xxiii. p. 10, 1887–8; and *American Journal of Science*, Series 3, vol. xxxiv. p. 345, 1888; NATURE, vol. xxxvii. p. 114, December, 1887.

4 "The Meteoritic Hypothesis," by Sir J. N. Lockyer (Macmillan and Co., 1890), p. 176:—Table of Carbon-Spectrum Comets.

5 *Proceedings* of the Royal Society, vol. xliii. pp. 117–156, November, 1887.

6 *Proceedings* of the Royal Society, vol. xliv. pp. 1–93, April, 1888; and ("Appendix to the Bakerian Lecture") vol. xlv. pp. 157–262, November, 1888.

America,[1] with the giant telescope of the Yerkes Observatory's enormous power, that the green and citron hydrocarbon's chief band-lines can be observed dark on the photosphere at the sun's edge, and close by, bright in the chromosphere to a height from the sun's edge which they estimated not to exceed 1″ of arc, or about 500 miles, to completely ratify the foregoing views that those low gas-flame's fluted bands are produced by carbon vapour at an exceedingly high temperature; and fully to justify the first observers in England and America of the presence of carbon in the sun, in the opinion which they independently expressed, that the temperature of the glowing region of the sun's atmosphere where this carbon vapour is produced and made to incandesce, must certainly approach nearly to, and at the same time not much exceed, that of the electric arc.

Carbon substance furnishes yet another known form of gaseous spectrum, which consists only of a few sharp bright lines, quite free from bands of shaded light, or flutings; and this linear form of its spectrum may be pretty certainly ascribed to carbon vapour in its simplest molecular, perhaps even monatomic, state of aggregation, since it is only obtained by heating carbon in a condensed electric spark to the highest possible artificial temperatures. No indications, however, of carbon's occurrence at this exceedingly high temperature in any celestial spectra, appear as yet to have been met with. Although no gaseous spectra produced at such high temperatures as those of the condensed electric spark were spectroscopically measured by the late Prof. Piazzi Smyth, yet a depiction of this carbon spectrum as it was first seen in the Leyden-jar spark between carbon poles by Ångström in 1863, and as it was represented by Ångström and Thalen in their "Spectres des Metalloïdes" in 1875, is given with the line-spectra of common air, hydrogen, nitrogen and oxygen and of vapour of mercury, by different authors, in the Plate of full-length spectra of his "High Dispersion Spectrum" Paper of 1884, by the late Prof. Smyth, to compare with his own measurements of low temperature spectra of the same elementary gases or their compounds. The map of the carbon line-spectrum given by Ångström and Thalen shows a spectrum-field extremely bare of lines, but terminated, at its two ends, by two very bright ones, a red, closely double line almost coincident with Fraunhofer's C, or Hα, and a violet one close-following G and the violet hydrogen line Hγ, and like the hydrogen-lines appearing to be easily widened into a diffuse, broad line by taking the spark in gases at increasing pressures.[2]

A faint single line near E, and two groups of three and four moderately bright, pretty close-packed lines near the beginnings of the two brightest (green and citron) flutings of the Bunsen-flame, or "hot-carbon" band-series, are all the remaining visible portions of this spectrum figured, as they had excellently observed and studied it, by Profs. Ångström and Thalen. But the latter two isolated line-groups appear to fit on remarkably well to the view already apparently borne out and substantiated by what precedes, that with rising temperatures and increasing disgregation of carbon-vapour molecules, the interval between the beginnings of the green and citron flutings becomes wider in passing from the "cool" to the "hot" carbon-band series. For while those band-beginnings are respectively at $\lambda = 519{\cdot}70$ and $560{\cdot}75$ (distance $= 41{\cdot}05\mu\mu$) in the cool, or oxy-carbon set, and at $\lambda = 516{\cdot}40$ and $563{\cdot}34$ (distance $= 46{\cdot}94\mu\mu$) in the hot, or hydrocarbon set of bands, the front-lines of the "Excelsior" Carbon-spectrum's (as the late Prof. Piazzi Smyth poetically termed it), or still hotter and more broken-up carbon-vapour molecules' two small solitary line-groups, are at $\lambda = 515{\cdot}05$ and $569{\cdot}41$, in Ångström and Thalen's Table of these carbon lines; both shifted again slightly in position in the same left and right directions as before, and with the interval between them again increased a little, now, from its last measures, $41{\cdot}05$ and $46{\cdot}94$, to $54{\cdot}36\mu\mu$.

But a most industrious explorer, and a describer and recorder unsurpassed in the skill of his depictions of the surprising beauties of all this rich domain of matter's spectroscopic radiations, we must again here grieve to note, has passed away. Besides his already-mentioned extremely perfect measurements of "gaseous spectra," the late Prof. Smyth's published spectrum-maps and spectroscopic writings comprised long descriptions too of not less than five full series of measurements with high dispersion, in southern skies, and with great magnifying powers, of the dark lines of the solar spectrum.[1] These graphic solar-spectrum maps and those of the "gas-spectra," and separate papers treating also of the oxygen-gas spectrum singly, and of the dark line group "*b*" in the solar spectrum by itself,[2] together form a lasting store of precious materials for spectroscopic study too variously instructive and often suggestive of interesting theoretical deductions from their well-recorded details, to be here dealt with shortly and concisely. It is with a sense of doing only very partial justice to the exceedingly high merit and scientific value of those other important spectrum records and researches, that as much space as could be accorded to these short notes has been devoted here to pourtraying only the increasing cosmical significance and the widely-spreading applications in spectroscopic astronomy, of his valuable investigations of the ordinary forms of carbon spectra. In his effectual unravelling of the mazy linelet systems of those familiar spectra's bands, a plain and simple law of sequence in the linelets' spectrum-places was disclosed, which some years later also proved the proper clue to elicit order from the complex-looking linelet structures of the dark absorption-bands, "A" and "B" (both due to oxygen in our terrestrial atmosphere), at the red end of the solar spectrum. Although those shaded groups' constructions were only perfectly made known at last in 1893, by Mr. G. Higgs, of Liverpool,[3] from the beautiful figures of them given in his then published "Photographic Studies of the Solar Spectrum," yet the drawings of those bands in Prof. Smyth's Madeira and Winchester Solar Spectrum Plates in 1881 and 1884, only second to Mr. Higgs' photographs in their clear discriminations and accurate positions of the bands' details, would have certainly afforded ripe enough materials to establish at least the major portions of their simple featured laws of linelet sequence by themselves, if they had been searchingly examined, and carefully enough discussed and studied for the purpose.

Further examples of the same simple law of linelet intervals in such "shaded" bands (where each distinguishable *suite* or tier of linelets exhibits simply a fixed and uniform excess or growth of interval—of each *suite's* own amount or proper measure—in every pair of adjoining lines, over that of its immediately preceding line-pair, as the rank of lines advances from the brighter to the dimmer region of the shading) occur, moreover, not only in the brightest, green, but also in the citron and the blue band-figures, very plainly, of Prof. Smyth's full-plate "high dispersion" maps of those three most notable light-ridges in the "carbon oxide" (or "cool carbon") spectrum. Another interesting indication of line-systems also can be traced in his full-length mapped array of the four then known low temperature lines of oxygen, three of which he discovered to be finely triple, and to which he contributed three more just similarly triple lines. Two Balmer's series of three lines each can be pretty certainly distinguished in this strikingly peculiar group of six mapped triplets, converging approximately to a nearly common progression-head, or series-limit, at about $\lambda = 430\ \mu\mu$. Possibly these two line-sequences which his much extended range and finely multiplied line-features of the ordinary tube-spectrum of oxygen appear to show, may have been already recognised and fittingly comprised by Messrs. Kaiser and Runge among the many such line-series which they have found indications of in the spectrum-field of oxygen. But these and many more such philosophical results may be looked for to be richly gleaned and brought to light by coming years' discussions of the minute and copious information which with Mr. T. Heath's skilful assistance in their draughtsmanship and computations, is lucidly unfolded in Prof. Smyth's noble works of well resolved and accurately measured ranks of lines both in the solar and in gaseous spectra. In those several sound and stalwart *opera*

[1] *Bulletins* of the Yerkes Observatory, No. 12, 1899.

[2] This widening of the carbon violet line to a "broad band" at $\lambda = 4272$ (Ångström, 4266·0) is very distinctly recorded in Dr. W. M. Watts' "Index of Spectra," 1872, "Carbon-Spectrum, No. IV."; where the groups and single lines, α, β (*plus* the two next lines), γ, and ι, compose together Ångström and Thalen's line-spectrum of pure carbon. With four or five exceptions, all the many lines contained in the several other line-groups besides these, in the same Carbon-Spectrum Table, can, however, be readily identified with lines of the oxygen line-spectrum mapped by Ångström and Thalen on the same Spectrum-Plate ("Spectres des Metalloïdes," Upsala *Nova Acta*, vol. ix. 1875) with their line-spectrum of carbon, and also with lines in Dr. Schuster's map (*Philosophical Transactions* of the Royal Society, 1879) of the line-spectrum of oxygen.

[1] At Lisbon, in 1877–78, with glass prisms (the whole visible solar spectrum), Edinburgh *Philosophical Transactions*, vol. xxix. 1880; in Madeira, in 1881, with a Rutherford's diffraction grating (21 special "subjects," or small regions of the solar spectrum); "Madeira Spectroscopic," Edinburgh, 1882; and at Winchester, in 1884, with a Rowland's diffraction grating (the whole visible spectrum, mapped *thrice*), Edinburgh *Philosophical Transactions*, vol. xxxii. 1886.

[2] Edinburgh *Philosophical Transactions*, vols. xxx. Part 1, and xxxii. Part 1.

[3] *Proceedings* of the Royal Society, vol. liv. p. 200, October 1893.

magna of spectroscopic explorations, we may surely feel convinced that after-times will neither fail to be gratified with results of scientific consequence, nor find it easily possible to overlook the great accessions made by the late Prof. Piazzi Smyth to spectroscopic science, by his boldly-planned recourses to, and ingeniously contrived employments of, great optical power and very high dispersions. A. S. HERSCHEL.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—At a meeting of the Junior Scientific Club, held on Friday, May 18, Dr. Mann gave a *résumé* of the history of the nerve cell from Malpighi's and Leeuwenhoek's time up to the present. He showed the advance due to the introduction of new methods, viz. chromic acid by Hannover, Golgi's and Ehrlich's methods, and the Picro-corrosive sublimate method of the author. Ehrenburg in 1833 discovered the nerve-cell, Beale in 1863 the nerve-fibril, Flamming and Nissl the basophil substance of the cell, which, as Mann was the first to show, becomes used up during functional activity. Hohngren's observations on material fixed by Mann's methods had demonstrated the universal occurrence of intracellular lymph channels in nerve-cells. Finally it was suggested that the basophil substance (Nissl's bodies) should rather be regarded as the homologues of Zymogen granules than as reserve material in the strict sense of the word.—Mr. A. D. Darbishire (Balliol) showed a number of living crustaceæ by microscopic projection on to a transparent screen.

CAMBRIDGE.—The honorary degrees in law, science, and letters, were conferred in presence of a large and brilliant assemblage on June 12. Prof. Langley was unable to arrive from America in time to be present, but the American Ambassador, Lord Rosse, Sir Benjamin Baker, Sir Walter Buller and Prof. Poincaré attended, and received a cordial welcome. The following are the speeches delivered by the Public Orator, Dr. Sandys, in presenting to the Vice-Chancellor the under-mentioned recipients of honorary degrees for distinction in science:—

THE RIGHT HON. THE EARL OF ROSSE, LL.D.

Assurgit proximus Universitatis Dubliniensis Cancellarius, cuius pater munere eodem ornatus atque etiam Regiae Societati praepositus, Hiberniâ in mediâ instrumentum ingens stellis observandis olim construxit; cuius de fratre autem, navis celerimae inventore sollertissimo, omnibus notum est "quo turbine torqueat" undas. Ipse famam inter peritos adeptus est, non modo de lunae calore subtilius inquirendo, sed etiam stellarum nebulis remotissimis (ut Aristophanis a Nubibus aliquantulum mutuemur) ὄμματι τηλεσκόπῳ observandis. Habetis exemplar domus praeclarae scientiarum amore conspicuae, cuius caput dignitatis Academicae heres dignissimus exstitit. Qui abhinc annos octo Universitatis suae inter ferias saeculares tot honores in alios contulit, hodie fortasse nobis ignoscet, quod honos ipsi olim debitus praecepto illi Horatiano nimium paruisse visus est:—"nonum prematur in annum."

SIR BENJAMIN BAKER, SC.D.

Quantum miratus esset historiarum scriptor, Gaius Cornelius Tacitus, si providere potuisset fore aliquando, ut Caledoniae fretum, Bodotriae nomine sibi notum, duobus deinceps pontibus immensis iungeretur! Quantum miratus esset historiae pater ipse, Herodotus, si audivisset fore aliquando, ut vir quidam, ab insulis Britannicis sibi prorsus ignotis oriundus, fluminis Nili aquas redundantes duplici mole et aggere magno coerceret et Aegypti regioni immensae irrigandae conservaret! Operis utriusque magni conditorem magnum hodie praesentem contemplamur, qui non pacis tantum triumphis contentus, velut alter Archimedes, etiam Martis tormentorum inventor et machinator admirabilis exstitit. Atqui ne Martis quidem inter opera pacis causam revera deseruit; etenim scriptoris antiqui de re militari monitum non ignotum est:—"qui desiderat pacem, praeparet bellum."

SIR WALTER LAWRY BULLER, SC.D.

Coloniae nostrae remotissimae, Novae Zealandiae, inter decora conspicua numeratus, adest hodie vir regionis illius indigenarum linguae imprimis peritus, cui, propter merita eius egregia, gratiae saepenumero publice sunt actae. Adest vir qui etiam regionis illius avibus summâ curâ describendis atque arte eximiâ depingendis opus magnum dedicavit. Quantum autem liberalitati eius etiam nostra Academia debeat, Musei nostri parietes, avium et animalium aut prorsus aut prope extinctorum exemplis ornati, satis clare loquuntur. Ergo quem ipsa Regina, quem et Gallia et Germania et Italia honoribus cumulaverunt, eundem etiam nosmet ipsi, tot munerum non immemores, laudis nostrae diademate decoramus.

M. HENRI POINCARE, SC.D.

Sequitur scientiarum Academiae Gallicae socius illustris, scientiae mechanicae caelestis inter Parisienses professor insignis, societatis Regiae Londinensis inter socios exteros olim numeratus, astronomorum denique a societate Regia numismate aureo nuper donatus. Quantam laudem meritae sunt investigationes illae subtilissimae, de aestuum maritimorum natura universa, de molium liquidarum sese rotantium aequilibrio, de planetarum denique et satellitum cursu vario, ad exitum felicem ab hoc viro perductae! Studiorum mathematicorum in utrâque provinciâ, et analyticâ et physicâ, propter scientiae suae prope infinitam varietatem inter principes numeratus, quam egregie nuper ostendit quantum provinciae illae vicinae invicem inter sese deberent! Quam pulchre studiorum suorum voluptatem cum artis musicae et artis pingendi voluptate comparavit! Quam ingenue mathematicam physicam confitetur novam quandam linguam desiderare; linguam cotidianam nimis exilem, nimis ambiguam esse, quam ut aliquid tam delicatum, tam subtile, tam varium, possit exprimere. Et nos idem hodie libenter confitemur: viro tali pro meritis eius tam variis laudando lingua nostra vix sufficit. "Conamur tenues grandia."

THE Knightsbridge Professorship, vacant by the resignation of Dr. Sidgwick, will be filled up on Saturday, June 30. Candidates are required to send their names to the Vice-Chancellor by June 25.

Mr. G. F. C. Searle has been appointed a university lecturer in experimental physics; and Dr. G. H. F. Nuttall, university lecturer in bacteriology and preventive medicine.

The first award of the Raymond Horton-Smith Prize has been made to Mr. A. B. Green, for his M.D. thesis on amyloid disease.

Mr. W. A. Macfarlane-Grieve, M.A., Oxford and Cambridge, of Impington Park, has offered to the University a farm of about 145 acres near Cambridge, free of rent till Michaelmas 1909, for the purposes of the Department of Agriculture. This handsome offer has been gratefully accepted on behalf of the Board of Agricultural Studies, to whom the management of the experimental farm is assigned.

The *University Reporter* for June 12 contains an interesting report on Mr. W. W. Skeat's exploring expedition to the Malay provinces of Lower Siam.

The Right Hon. A. J. Balfour, M.P., will deliver the inaugural address to the students of the Vacation Courses, arranged by the University Extension Syndicate, at 12 noon on Thursday, August 2.

The Arnold Gerstenberg Studentship in moral philosophy for graduates in natural science has been awarded to Mr. T. J. Jehu, of St. John's College, who holds a Heriot Fellowship in geology from the University of Edinburgh.

The Mathematical Tripos list is unusually short this year. The sixteen wranglers are headed by Mr. J. E. Wright of Trinity, Mr. A. C. W. Aldis of Trinity Hall being second wrangler. An Indian student, Mr. Balak Ram of St. John's is fourth; and Miss W. M. Hudson of Newnham College, sister of the senior wrangler of 1898, is bracketed eighth wrangler. Miss E. Greene, also of Newnham, is equal to tenth. St. John's claims five of the wranglers, Trinity four, Clare two.

In Part II., the bracketed senior wranglers of last year, Mr. Birtwistle of Pembroke, and Mr. Paranjpye of St. John's, are placed with two others in the first division of the first class.

MR. CHAMBERLAIN, Chancellor of Birmingham University, has received a letter from Mr. W. H. Foster, Apley Park, Bridgnorth, offering a donation of 2000*l*. towards the endowment fund.

MR. J. G. CLARK, whose death is announced from Worcester, Massachusetts, was a generous promoter of the interests of education in the United States. By his efforts the Clark University at Worcester, Mass., was founded "to increase human knowledge and transmit the perfect culture of one generation to the ablest youth of the next; to afford the highest education and opportunity for research." He gave a close study to the